

INVESTIGATION OF MINERAL MATTER CONTENT OF HUSKS SEPARATED FROM BARLEY VARIETIES CULTIVATED IN TURKEY

Ömer Yılmaz^{1,a}, Onur Koyuncu^{2,b,*}



¹Biotechnology Research Center, Field Crops Central Research Institute, Republic of Turkey
Ministry of Agriculture and Forestry, 06170 Yenimahalle, Ankara, Turkey

²Eskişehir Osmangazi University, Faculty of Arts and Sciences, Department of Biology
Meşelik, 26040, Eskişehir, Turkey

*Corresponding Author:

E-mail: onurkoyuncu72@gmail.com

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a:  ORCID 0000-0003-0365-4838, b:  ORCID 0000-0002-0364-6638

ABSTRACT. In this study, 28 barley varieties that are produced in Turkey and that have come to the fore in recent years were used. The husks of the collected varieties were separated from their husks in an air pressure husk separator. The husks were ground to pass through a 0.5 micron sieve and made ready for analysis. Mineral substance determinations were made in ground husks. According to the results of the mineral substance analysis carried out in the husk samples, the amounts of Ca, Mg, K, Fe, Na, Si, Al, Mn, Ni, Cu, Zn, Ba minerals in the barley husks are 1158.84-3873.75 mg/kg, 442.97-2238.77 mg/kg, respectively. , 939.14-2441.83 mg/kg, 204.36-1243.61 mg/kg, 98.49-1406.51 mg/kg, 273.31-1658.37 mg/kg, 38.53-569.18 mg/kg, 9.99-30.33 mg/kg, 0.37-6.80 mg/kg, It was found between 1.09-4.97 mg/kg, 1.34-6.35 mg/kg, 1.33-8.72 mg/kg. At the end of the study, it is thought that barley husks are rich in mineral substances and can be used in various applications.

Keywords: Husk, Barley, Mineral, Macro element, Micro element, Turkey

INTRODUCTION

Barley is a diploid, annual grain with seven pairs of chromosomes. The barley grain is approximately 3-4 mm wide, 8-12 mm long and 2-3 mm thick, and these sizes vary according to the variety and especially whether it is six-row or two-row and sparse or dense. It is classified as 2-row (*Hordeum distichum*) and 6-row (*Hordeum vulgare*) according to the number of rows and awn structure in the spike [1]. It is the second important grain produced in Turkey after wheat. In prehistoric times, people used barley as food, which is traditionally limited to use in food compared to other grains and is generally used for brewing and animal feed. Today, barley; It attracts wide attention in food applications due to its protein, dietary fiber, (especially soluble β -glucan) and rich starch content [2].

Barley is very rich in mineral matter and has a vital importance in human and animal nutrition [3, 4]. By participating in the structure of tissues and organs, mineral substances regulate the acid-base balance and osmotic balance in the body. In addition, they take part in the fulfillment of metabolic activities by participating in the structure of some vitamins, hormones and enzymes, and in the stimulation of muscles and nerves. However, since organic compounds cannot be synthesized from the bodies of animals, the need for mineral substances is met with external feeds [5].

Husks are separated from barley during production and used as waste material. Kavuz is a light, easy to transport, organic and rich content material that can be easily found in Turkey, is cheap, does not cause environmental pollution, can be used immediately from production areas. In our country, it is generally used as a litter in chicken farms and in iron and steel facilities [6].

It is thought that the husk contains cell wall components such as hemicellulose and lignin, as well as a rich structure in terms of nutritional content and mineral substance content. In this study, the mineral content of separated barley husks, which is widely grown in our country and has come to the fore in recent years, was determined and the possibilities of using it as a functional food component were investigated.

MATERIALS AND METHODS

Material

The barley varieties used in the study were determined by the Field Crops Central Research Institute (TARM, Ankara), Transition Zone Agricultural Research Institute (GKTAE, Eskişehir), Aegean Agricultural Research Institute (ETAE, İzmir) and Trakya Agricultural Research Institute under the General Directorate of Agricultural Research and Policies (TAGEM). It was obtained from the Research Institute (TTAE, Edirne). The samples were harvested in 2018 and sent from the institutes.

Cleaning of Samples

In the study, foreign materials of barley samples were primarily separated with a cleaning device (Labofix' 90, Schmidt AG, Germany). In this device, broken and undersized grains are separated by the cylindrical sieve system, and dust and husk pieces are separated by the air flow.

Separation of Barley Husks

After the barley samples were separated from foreign matter and broken grains, the husks were separated from the husk separator (Codema, LH 5095, Minnesota, USA) working with compressed air.

Grinding The Separated Husks

After the husking process was completed, the barley samples, which were passed through the sample cleaning device and cleaned, were ground in a hammer mill (Perten 3100, Huddinge, Sweden) with a 500 μ pore size sieve and made ready for analysis (Figure 1).



Fig. 1. The husk sample that has been ground and prepared for analysis

Determination of Mineral Substance Amount

The amount of mineral substance was determined according to the method of NMKL (Nordic Committee on Food Analysis) 186, (2007) [7]. Samples are weighed in incinerators. With the addition of HNO₃ and H₂O₂, samples are burned at 200°C for 45 minutes in the microwave combustion system (Milestone Easy, Italy). Before starting the analysis, the mix calibration standard provided by the company is used. Analysis was performed on the samples according to NMKL 186, 2007 and in ICP-MS (Inductively Coupled Plasma-Mass Spectrometer) device (Thermo Scientific, USA). Spectrophotometer results are given in mg/kg on wet/dry matter.

Statistical Analysis

In this study, each analysis was repeated in triplicate and the averages with standard deviation values are given in the relevant tables. Statistical analyzes were performed in SPSS (18.0) statistical analysis package program. The status of the samples having a statistically significant difference on the basis of the relevant criteria was examined by one-way Anova analysis. The “P” statistical values have emerged as a result of the Anova test on the basis of each sample and the criteria it is evaluated. Related Post-Hoc tests were applied according to the Anova test values being less than 0.05. The technique used in Anova analysis was tested with the condition of homogeneity of variance of each sample and was subjected to the relevant Post-Hoc tests. Duncan Post-Hoc test was applied in case of homogeneous distribution of variances, and Games-Howell Post-Hoc test was applied in case of non-homogeneous distribution. The averages of the samples taken according to the relevant criteria are lettered as a result of clustering. Different letters indicate that the means are different from each other, and double letters are lettered to be close to the group averages before and after them.

RESULTS AND DISCUSSION

Microelement (Transition, Intermediate and Semi-Metal) Content in Husks

According to the results of the statistical anova analysis, it was found that the difference between the averages on the basis of minerals was statistically significant, since it was significant ($P < 0.05$) on the basis of each mineral among all varieties (Table 1). As a result of the evaluations on micro element analyzes made in husk, the lowest Mn element among the cultivars was determined in İmbat (9.99 ppm) and the highest in Pınar (30.33 ppm) cultivars. It has been determined that enzymes are necessary for electron transfer in plants and act as catalysts in physiological and enzymatic events [8]. Blanz *et al.*, (2019) investigated the effects of seaweed fertilization on the chemical and isotopic composition of barley and conducted different dose trials. They stated that Mn analysis was performed in barley grain, husk and straw, and it was found as 12.1 µg/g, 14.2 µg/g and 9.9 µg/g, respectively, in the control group[9].

Table 1. Micro element analysis results in husks separated from barley varieties

Variety	Mn ¹	Fe ¹	Ni ¹	Cu ¹	Zn ¹	Al ¹	Si ¹
Keser	17,86 ^k	567,79 ^{ij}	1,27 ^k	1,83 ⁱ	2,70 ^h	151,69 ^j	430,35 ^b
Erginel 90	24,46 ^t	411,06 ^e	1,26 ^k	1,86 ^j	1,92 ^c	180,66 ^t	492,30 ^c
Özdemir	23,59 ^s	897,28 ^s	1,76 ^p	2,21 ^o	3,53 ^m	364,20 ^r	489,13 ^c
Akar	10,15 ^a	204,36 ^a	0,37 ^a	1,09 ^a	1,34 ^a	43,84 ^a	273,31 ^a
İnce	19,41 ⁿ	575,83 ^j	1,40 ^m	1,75 ^{gh}	1,87 ^{bc}	212,07 ^m	650,53 ^d
Bilgi	18,44 ⁱ	453,29 ^d	1,36 ^l	1,72 ^g	2,91 ^j	38,53 ^a	704,17 ^e
Ünver	28,25 ^v	649,09 ^l	1,60 ⁿ	2,29 ^p	2,63 ^g	419,00 ^t	1274,14 ^o
Tarm 92	21,35 ^p	597,33 ^k	0,65 ^e	1,90 ^k	2,14 ^e	80,32 ^e	1584,37 ^r
Zeynelağa	19,30 ^{mn}	565,93 ⁱ	0,44 ^b	2,13 ⁿ	3,20 ^l	101,73 ^g	1158,48 ⁿ
Tosunpaşa	15,48 ^h	412,97 ^c	0,77 ^g	2,02 ^m	1,90 ^c	228,13 ⁿ	1034,81 ^k
Aydanhanım	18,98 ^m	539,21 ^g	0,63 ^e	1,77 ^h	1,84 ^b	70,56 ^d	843,32 ^g
Burakbey	12,66 ^d	491,71 ^e	0,37 ^a	1,26 ^d	1,38 ^a	90,19 ^f	656,48 ^d
İmbat	9,99 ^a	492,70 ^e	0,53 ^c	1,64 ^f	2,00 ^d	116,35 ^h	819,12 ^f
Bayrak	13,00 ^e	657,52 ^l	0,78 ^g	3,30 ^u	3,88 ⁿ	398,20 ^s	1061,34 ^l
Kayı	19,24 ^{mn}	722,83 ⁿ	0,79 ^g	1,19 ^c	2,42 ^f	61,97 ^c	816,98 ^f
Manyas	20,83 ^o	1243,61 ^y	0,99 ^j	1,14 ^b	3,09 ^k	58,97 ^{bc}	713,62 ^e
Atabeyi	14,36 ^g	532,89 ^g	0,52 ^c	1,66 ^f	4,43 ^s	56,00 ^{bc}	709,09 ^e
Alhisar	23,14 ^r	517,02 ^f	0,64 ^e	1,86 ^{ij}	4,28 ^r	42,72 ^a	1377,95 ^p
Sancak	15,87 ⁱ	925,20 ^t	0,69 ^f	4,97 ^v	4,72 ^t	97,62 ^g	937,19 ^h
Hilal	13,70 ^f	929,11 ^t	0,71 ^f	3,04 ^t	4,21 ^p	569,18 ^u	1106,73 ^m
Akhisar-98	10,84 ^b	782,06 ^p	0,85 ^h	1,56 ^e	5,39 ^u	67,35 ^d	968,05 ^t
Egebeyi	12,24 ^c	284,00 ^b	0,59 ^d	1,27 ^d	3,56 ^m	52,89 ^b	642,23 ^d
Pınar	30,33 ^z	769,02 ^o	6,80 ^s	2,20 ^o	5,47 ^v	138,93 ^t	862,84 ^g
Harman	22,94 ^r	871,12 ^r	1,00 ^j	1,93 ^l	6,35 ^y	176,77 ^t	993,31 ^j
Hasat	18,35 ⁱ	710,08 ^m	0,93 ⁱ	1,66 ^f	3,95 ^o	117,50 ^h	969,16 ⁱ
Bolayır	17,38 ^j	550,64 ^h	0,95 ⁱ	1,73 ^g	2,82 ⁱ	164,04 ^k	821,25 ^f
Hazar	23,28 ^{rs}	1120,43 ^v	1,63 ^o	2,53 ^s	6,33 ^y	243,11 ^o	1658,37 ^s
Martı	24,90 ^u	1012,74 ^u	5,05 ^r	2,37 ^r	4,41 ^s	279,52 ^p	805,67 ^f

¹ It is given in mg/kg (ppm).

Mean±standard deviation,(n=3)

The difference between the means shown with different letters in the same column is statistically significant (P<0.05).

Significant differences were determined between cultivars in terms of Fe content, which has a significant effect on protein synthesis. The lowest Fe mineral was found in Akar (204.36 ppm) and the highest in Manyas (1243.61 ppm). The lowest Cu mineral was detected in Akar (1.09 ppm) and the highest in Sancak (4.97 ppm) cultivars. Zinc, which has an important role in carbohydrate, protein and auxin metabolism in plants, also plays a major role in enzyme activities. The lowest Zn mineral was detected in Akar (1.34 ppm) and the highest in Harman (6.35 ppm) varieties. In a study on the nutritional value of wheat, triticale, barley, spelt and oat grains, micro element levels were examined and Zn, Fe, Cu and Mn contents were determined. Zn contents were found as 32mg, 25mg, 23mg, 21mg and 28mg, respectively. They stated that the Fe content was 39mg, 37mg, 76mg, 41mg, 35mg, and the Cu content was 7.4mg, 3.4mg, 3.3mg, 4mg, 4.3mg, and the Mn content was 48.8mg, 26mg, 22mg, 39mg, 43mg, respectively [10].

The lowest Ni mineral was detected in Burakbey (0.37 ppm) and the highest in Pınar (6.80 ppm) cultivars. Al mineral was detected in the lowest Knowledge (38.53ppm) and highest Crescent (569.18 ppm) cultivars. Si mineral was detected the lowest in Akar (273.31 ppm) and the highest in Caspian (1658.37 ppm) varieties. Hernández-Martínez, *et al.*, (2020) reported that it can be used as an environmentally friendly system to contribute to the production of clean energy at low cost and in a study on the production and characterization of silicon (Si) from wheat husk ash for its possible application in solar cells. These ratios were found in normal amounts for husk since mineral substances play a major role in the enzymatic reactions of plants [11].

Macro Element (Alkaline and Soil Alkaline) Content in Husks

According to the results of the statistical anova analysis, it was found that the difference between the averages on the basis of minerals was statistically significant, since there was significance ($P < 0.05$) for each mineral among all cultivars (Table 2). When the macro element analysis results of the husks separated from the barley cultivars are examined, the lowest Na mineral was found in Akar (98.49 ppm) and the highest in İmbat (1406.51 ppm). The lowest mineral K was detected in Akar (939.14 ppm) and the highest in Caspian (2441.83 ppm) varieties. It has been reported that potassium is of great importance for plants, as it has important roles in enzyme activity, regulation of water in the plant, photosynthesis, sugar and protein content of grains [8]. Mg mineral was found the lowest in Akar (442.97 ppm) and highest in Ünver (2238.77 ppm) cultivars. The lowest amount of Ca mineral was found in Akar (1158.84 ppm) and the highest in Harman (3873.75 ppm) varieties. In the Ba mineral, the lowest was detected in Manyas (1.33 ppm) and the highest in Bolayır (8.72 ppm) cultivars. Biel *et al.*, (2020) determined the amount of macro elements in a study on the nutritional value of wheat, triticale, barley, spelt and oat grains. According to the K, P, Na, Ca and Mg analysis results, in wheat 4.14g, 3.44g, 0.17g, 0.37g, 1.51g triticale 4.70g/kg, 3.85g/kg, 0.17g/kg, 0.4g/kg, respectively. 1.1g/kg barley 4.4g/kg, 3.6g/kg, 0.10g/kg, 0.4g/kg, 1.8g/kg spelled oat 3.67g/kg, 3.60g/kg, 0.17g/kg, 1.31 g/kg, 1.39g/kg hulled oats were reported as 2.41g/kg, 4.59g/kg, 0.16g/kg, 1.07g/kg, 1.18g/kg. In the study on the total product formulation of wheat flour enriched with whole cowpea husk (*Vigna unguiculata* (L.) Walp.) and barley husk (*Hordeum vulgare*), P, Fe, Mg, Ca, and Mn analyzes were performed on barley husks and the results were 11.16 mg, respectively. It has been stated that it is found as /100g, 2.46 mg/100g, 1.73 mg/100g, 4 mg/100g and 14.21 mg/100g [12]. In a study by Salama *et al.* (1997) on the chemical composition, nutritional value and functional properties of malt sprouts, analysis was made for 9 minerals in the husk part [13]. Accordingly, Ca 11.830 g/kg, P 6.530 g/kg, K 1.160 g/kg, Na 0.98 g/kg, Cu 0.007 g/kg, Fe 0.240 g/kg, Mg 0.050 g/kg, Mn 0.020 g/kg and Zn were found to be 0.070 g/kg. In a comparative study on the use of wheat bran and barley husk as nutrients in rats, Ca, P and Zn analyzes were made in barley husks and they stated that Ca 1.13 g/kg, P 2.77 g/kg, Zn 27.6 g/kg [14].

Table 2. Macro element analysis results of husks separated from barley varieties

Variety	Na ¹	K ¹	Mg ¹	Ca ¹	Ba ¹
Keser	400,61 ^g	1459,51 ¹	1376,52 ^h	2081,82 ¹	4,20 ⁿ
Erginel 90	498,63 ^h	1473,16 ^k	1341,48 ^h	1541,87 ^d	5,53 ^t
Özdemir	393,03 ^g	1450,13 ^{hi}	1737,67 ^l	2924,34 ^u	4,83 ^r
Akar	98,49 ^a	939,14 ^a	442,97 ^a	1158,84 ^a	2,60 ^f
İnce	623,79 ^j	1460,05 ¹	1506,50 ^j	2348,19 ⁿ	4,40 ^o
Bilgi	651,67 ^k	1464,36 ^j	1420,12 ¹	1648,85 ^e	4,75 ^p
Ünver	323,83 ^e	1456,85 ^{hi}	2238,77 ¹	2998,26 ^v	4,10 ^m
Tarm 92	579,96 ¹	1978,85 ¹	2153,97 ^s	2515,43 ^s	2,90 ^h
Zeynelağa	1350,30 ^v	1457,32 ^{hi}	2020,23 ^p	2144,06 ^j	8,08 ^y
Tosunpaşa	320,89 ^e	1411,20 ^{fg}	994,02 ^d	2336,76 ⁿ	6,41 ^u
Aydanhamı m	691,10 ^l	1390,80 ^e	1366,60 ^h	1755,06 ^g	2,01 ^d
Burakbey	269,27 ^c	1071,13 ^b	1002,14 ^d	1409,80 ^c	1,86 ^c
İmbat	1406,51 ^z	1452,13 ^{hi}	2079,41 ^f	2208,57 ^k	2,74 ^g
Bayrak	1378,56 ^y	1469,93 ^{jk}	2163,73 ^s	2314,88 ^m	3,39 ^k
Kayı	943,46 ^o	1451,47 ^{hi}	905,30 ^c	1680,11 ^f	1,36 ^a
Manyas	1120,75 ^r	1316,01 ^d	1143,59 ^f	1281,23 ^b	1,33 ^a
Atabeyi	1223,53 ^t	1271,03 ^c	1682,69 ^k	2047,30 ^h	3,71 ^l
Alhisar	930,50 ⁿ	2141,46 ^m	1418,77 ¹	2874,70 ^t	4,21 ⁿ
Sancak	768,32 ^m	1446,03 ^h	1795,58 ^m	2406,29 ^o	2,59 ^f
Hilal	1276,11 ^u	1448,27 ^{hi}	1864,19 ⁿ	2496,39 ^r	1,66 ^b
Akhisar-98	1173,30 ^s	1418,87 ^g	1920,22 ^o	2265,93 ^l	3,14 ¹
Egebeyi	1027,71 ^p	1404,33 ^f	1218,74 ^g	1638,85 ^e	3,29 ^j
Pınar	218,62 ^b	1384,89 ^e	1343,16 ^h	2425,14 ^p	6,56 ^v
Harman	348,18 ^f	1464,50 ^j	1196,14 ^g	3873,75 ^z	2,86 ^h
Hosat	304,72 ^d	1413,22 ^{fg}	1043,89 ^e	2388,43 ^o	5,34 ^s
Bolayır	262,27 ^c	1416,22 ^g	733,70 ^b	2875,40 ^t	8,72 ^z
Hazar	581,44 ¹	2441,83 ⁿ	1726,75 ^l	3733,97 ^y	2,18 ^e
Martı	577,02 ¹	1456,86 ^{hi}	1074,18 ^e	1765,40 ^g	4,11 ^m

¹ It is given in mg/kg (ppm).

Mean±standard deviation,(n=3)

The difference between the means shown with different letters in the same column is statistically significant (P<0.05).

Results

Barley husk, one of the wastes of plant origin, is one of the materials that has been considered to be evaluated recently. The husks separated from the grain do not have much use. Husks, which we see as vegetable waste, is also seen as a material that can provide advantages in terms of usage areas in the future.

When considered from another perspective, husk can be considered as a waste material rich in Si and its use as a clean energy source can be paved the way. Husks, which is rich in inorganic substances, can also be used as an energy source.

With the development of modern agricultural practices, the industry is also growing and the food sector is developing day by day. The use of husk, which we refer to as waste, in soilless agriculture and the high amount of Ca, Mg, K, Fe, Na, Si and other elements it contains can be turned into plant food and used. It is thought that it can also be used in the food industry due to its rich mineral content.

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